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## Education for complex problem solving

*Problem-Based Learning as one kind of answer to Higher Education challenges today?Case: a Danish University*

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# Education for complex problem solving

**Problem-Based Learning as one kind of answer to Higher Education challenges today? Case: a Danish University.**

Lone Krogh

*“Problem-based learning is both pedagogical approach and curriculum design methodology. Simultaneously it develops higher order thinking and disciplinary knowledge bases and skills. It places students in the active role of problem-solvers (practitioners) and confronts students with a real-world situations.....” (Barrows, 1986, p 481)*

## **Key words**

Problem solving. Projects. Teams. Collaboration. Student-direction.

Interdisciplinary. Finding solutions (often in collaboration with firms and organizations outside the university). The teacher as supervisor/facilitator.

## **Introduction**

The Problem-Based Learning model as it is practiced at Aalborg University grew out of expectations for future graduates in the 1970s. Many changes and developments have taken place since then in the ways the principles and methodologies are practiced, due to changes in society and governmental regulations. However, the basic educational principles and methodologies are still the same and seem to meet expectations from society and academic work places today. This is what surveys and research, done regularly, document. (see for instance Krogh, 2013).

Aalborg University, situated in the northern part of Denmark, has more than 40 years of experiences with practicing PBL methodologies. The aim of this paper is to focus on and to discuss why and how a PBL approach may be a relevant educational approach for Higher Education these years in meeting

current challenges. The core principles and methodologies of the PBL approach at Aalborg University will be unfolded, by drawing in different kinds of experiences (possibilities and challenges).

One of the key points is that the principles and the methodologies, including the aspect of inter-disciplinarily to a large degree both support students' development of academic knowledge, skills and competences for the academic labour market and simultaneously correspond research methodologies. By applying this approach during all semesters of the education students actually acquire competences, which are relevant for a university career and a career at the academic labour market outside universities.

“... what you specifically learn at university is difficult to tell somebody, for instance being able to build a radio or something similar. This is something you have to learn later on but you have found your way. What matters is the way in which you learn at Aalborg University. It makes up 80 % of the way in which we work. It is crucial because more than the exact knowledge has been put into their heads.”

( A director from a big firm, in Krogh, 2013)

### **Augments for applying the PBL principles and methodologies**

Changes in society have had an impact on the labour markets in relation to types of work functions, production technologies, company structures as well as industrial dynamics. Things have become more complex and unpredictable, technologically as well as in terms of knowledge, qualifications, competencies, values and attitudes among employers and employees. It has been explained as a change from the industrial society to the information society, the knowledge society, and even to the learning economy and society (Lundvall, 2008).

These tendencies influence the requirements for professional, general and personal competencies of academics. Relating to the professional foundation of disciplines within the individual subject and profession, we see a demand for abilities in development, planning, communication, knowledge, creativity, collaboration, theoretical reflecting, problem solving, ethics, action and accountability. These abilities are often referred to as the 21<sup>st</sup> century skills (see for instance Crockett, 2016). Specific requirements to academics are of course varying very much depending on the kind of job, - being in universities, in public administration, consultancies or in other kinds of knowledge organisations. In general the so called 21 century skills and competences are in high demand. Facing the demands of these kinds of competences has to lead to revision of some of the teaching strategies at Higher Education institutions in order to prepare students to be able to meet the demands from the labour market and from society. Referring to Bowden and Marton (1998), students must develop competencies designed for a society, which develops in yet unknown directions. Based on an understanding of the role of the universities the research community, the teachers and the students are the ones who possess the capabilities, which are necessary in building up sustainable solutions for the future world's challenges.

Universities are in focus as important players and partners in the diffusion of new knowledge to society by means of the research and by well-educated candidates.

The importance of understanding the relationship between universities and society is connected to the social dynamics described within the concept of the knowledge or the learning society (Lundvall, 2008). All kinds of jobs and other social functions within this concept have to be dealt with more dynamically by individuals within a specific social context. Therefore

substantial weight is put on words such as flexibility, dynamics, human resources, quality, collaboration skills , individual and organisational learning. What does this mean to university education? Universities are increasingly forced to operate within the context of new management forms and new economic models. At the same time universities have to diffuse knowledge within the context of the university, characterized by wide scale diversity among students. The challenge is to find education strategies, which will support the diversity of students in developing the relevant academic skills and competencies.

### **The creation and practice of PBL-principles and methodologies at Aalborg University**

Problem-based learning, project work, etc. are concepts used widely and with different meanings, integrated into varying educational designs and with different instructional goals. The original idea and theoretical foundation of the problem-oriented project-work in a Danish context was formulated by Illeris (1974) in his seminal book, *Problem orientation and participant direction: An introduction to alternative didactics*. The PBL-pedagogies at Aalborg University were developed from these original principles. Exemplarity, open curriculum, interdisciplinary and experience-based learning, peer learning, and collaborative learning in groups were important concepts (Aarup Jensen and Krogh, 2013). These concepts are concepts, which characterize the PBL model today at Aalborg University. They will be expanded on in the following.

The Danish researcher, Illeris, was one of the core persons in implementing the PBL strategies in Denmark from the 1970ties. He lists three categories of qualifications which appeared to be necessary for the development of society at that time: 1) skills which can be defined in direct relation to a given task or

work process, 2) adaptive qualifications of a general character and comprising attitudinal characteristics (e.g. diligence, perseverance, vigilance etc.) – combined with a willingness to apply these characteristics in relation to work, to accept and subject to the existing work processes, 3) creative/innovative qualifications that may be divided into qualifications for scientific, innovative work and qualifications for continuous renewal and the ability to collaborate. (Illeris, pp. 32-35). Referring to Piaget's theory of learning Illeris explains accommodative learning processes as a prerequisite for creativity. From this point of departure he describes an expedient learning process, that allows for the development of skills, adaptive ability and creativity in a process which alternates between accommodative processes (the creation of new cognitive structures) and assimilative processes (the incorporation of new material in the individual's existing structures). Such alternating processes are a precondition of student's ability to acquire holistic competences that comprise skills, an adaptive ability and creative qualifications, which according to Illeris' analysis were needed by society at that time, and still is (Illeris, pp. 76-77).

Illeris developed these ideas further to an alternative didactic concept – the problem-oriented project-work, characterized by the following principles:

- **Problem-orientation**, which means that the point of departure for the students is the subject related knowledge, methods and theories relevant to the specific problem rather than a narrow discipline-bound theme or task. Consequently, interdisciplinarity becomes a core principle.
- **Participant direction**, which means that it is the students, who define the problems (the research questions) and chose the work

methods.

These are important principles for the creation of possibilities for the accommodative learning processes, which are necessary for developing creativity and flexibility. However, if teachers or the educational system determine which problems should be the point of departure and how students are supposed to work with problems, the traditional borders between disciplines may have been transgressed, but new political agendas delimitate and constrict in the same way as the old ones and hinder students' accommodative learning process (Illeris, 1982).

Significantly, the problems in question needs to be and should be experienced as relevant for the individual student in order to ensure accommodative learning processes, which depend on commitment. Accommodative learning processes are demanding and will only take place in situations of significance for the individual student, where something is at stake. Otherwise, the individual student will dismiss the problem or only assimilate it, i.e. integrate it into already established cognitive structures. (Illeris, pp. 82-83). The principles are:

- **Exemplarity**, which means working with the important and representative aspects, exemplifies the area of the discipline in question. Transferable skills will be developed.
- **Group work**. Students collaborate in groups about problem solving. In this way they learn the difficult art of collaboration and project leadership.

### **The work process in practice**

Ideally problem- based project work will go through the following phases,

- Selection of the theme and the first problem raising;
- Formulation of the project (corresponds to “problem formulation” often used in the PBL- terminology);
- Methodological reflections and decisions on how to solve the questions raised in the problem formulation;
- Project work (i.e. theoretical and empirical work, perhaps involving experiments and field work);
- Production (of a project report) (sometimes involving descriptions of reflections on work processes); and
- Product assessment (group exam), and if necessary – product adjustment.

Formative assessment and feedback from supervisors and fellow students during the semester provide valuable input in the working process. This may take place as a part of the continuous work processes and feedback from fellow students and supervisors. Further it can also be more formalised in opponent seminars taking place regularly during the semester.

Problem-oriented problem-based project work may be interpreted and implemented in a number of different ways according to educational institutions, disciplines, subjects, and learning goals. There may be varying degrees of free choice regarding the specific problem, subject area, and methods, and the project work may differ in size (ECTS<sup>1</sup> points), i.e. the students’ workload per semester. Furthermore, there may be vast differences in resources allocated to the project work in terms of hours of supervision from teachers as well as study facilities (rooms) for the groups to work in.

Although the facilities and resources for project work may vary, the following

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<sup>1</sup> European Credit Transfer System



model illustrates the elements which generally forms part of the problem oriented project work at Aalborg University (see fig. 1)

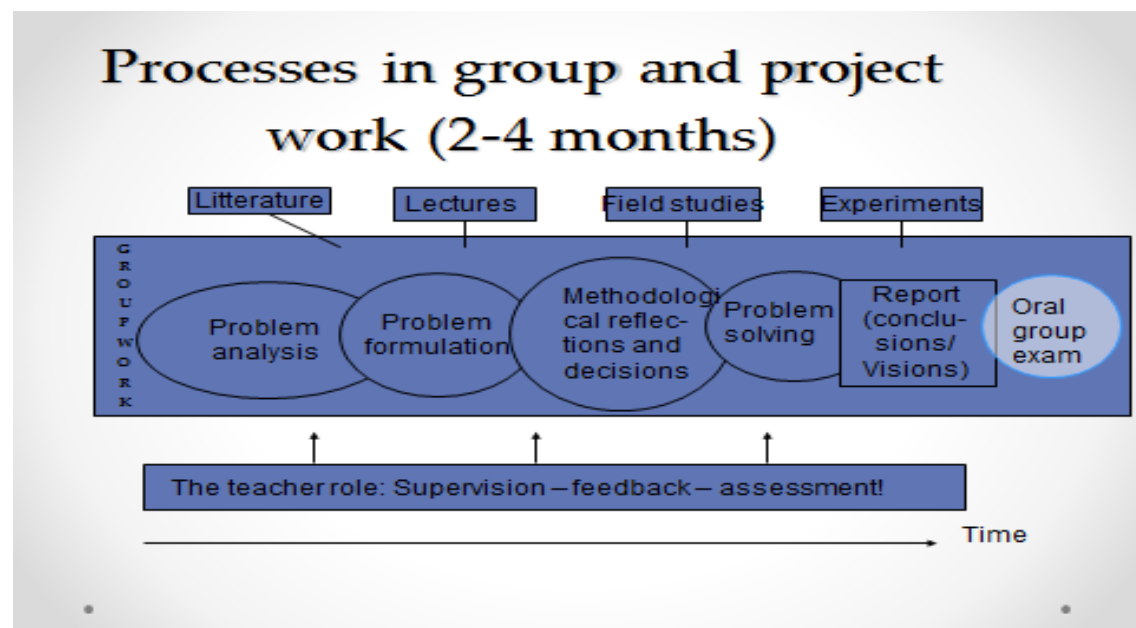


Fig. 1 shows processes and resources available for the problem-based project work at Aalborg University

The project work is combined with lectures, seminars or laboratory work on relevant subject matters. The actual organisation of the study program depends on the analyses regarding alignment between learning goals in context, reasoning the use of problem oriented project work , and recommendations put forward by a study board and teachers. The intentions are that all sources and methodologies aim at supporting the students in their working processes and in developing the relevant knowledge, skills and competences. The students' work is facilitated by university teachers supervising them and their project work. Generally it is expected that students work in groups of 3-6 persons during the first year of study, which may later on in their studies shrink down to 3 or 2 students per group. Individual project study is accepted, but the students are told that this minimizes the possibility of peer-learning and

feedback from supervisors.

Figure 2 shows the allocation grade between project work and other activities in general.

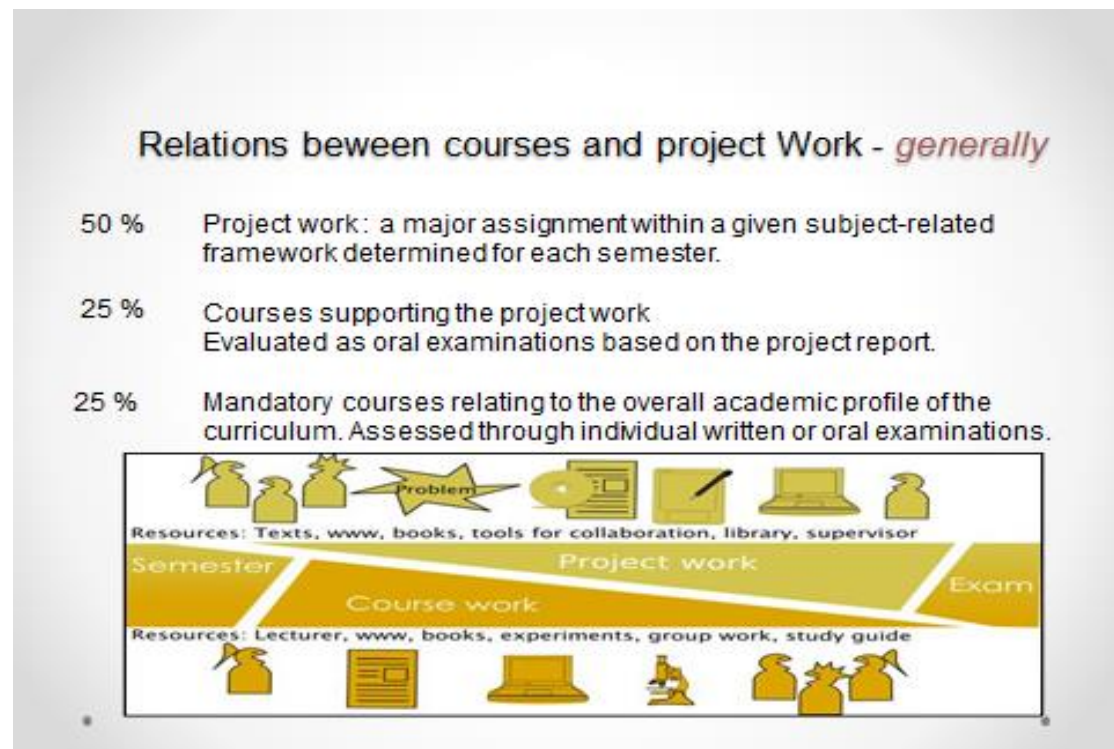


Fig. 2. The allocation grade between project work and other teaching activities generally

In reflection of the different disciplines, their needs and practices there are a number of different versions of project work; however they all share the presented core PBL principles such as problem orientation, student direction, exemplarity, group work, interdisciplinarity, group exam and the teachers as supervisor/facilitator.

At the end of a semester the students finalise their project work with an oral group exam, where all students are present and with the supervisor (teacher) and external censor as discussants. During the exam the students present the problems, they have been working with, the results and the theories and methodologies they applied. The students are assessed individually based on

the joint product and their behaviour during the exam. The more students in the group the longer time there is left for the assessment process. Because of the duration of the exam, the students have the opportunity to document extensive and complex knowledge in depth within the professional field in question. The assessment is based on a written project, on which the group of students has been working for usually 2-3 months previously. During the work process the students regularly have received formative feedback from the supervisor and their fellow students.



### **The teacher as supervisor and examiner**

As mentioned, each group is assigned a supervisor, who through the process helps, challenges, supervises, advises and discusses the work with the students and finally assesses them. The supervisor's assistance is, however, specifically important on several occasions, in both the selection and formulation of problems, methodological reflections and decisions, and in facilitation and formative feedback during the working process. Finally, the supervisor must be knowledgeable about the formal requirements and explain to the students how exams will take place in order to ensure valid

assessments of each individual student.

### **Documentation of the relevance of a PBL approach**

Aalborg University has for many years produced research to describe, evaluate and explore what is special about the PBL-principles and methodology, (for instance Adolphsen & Quist, 1995; Jæger, 1992; Kolmos & Rasmussen, 1994; Olsen, 1995) . Some of the more recent work includes two substantial surveys conducted in 2003 and 2009 involving graduates as well as employers, investigating for instance the connections between the PBL Aalborg model, the students' development of qualifications and competences and expectations from the national and international workplaces ([www.cand.aau.dk](http://www.cand.aau.dk), Krogh, 2013). Generally, the studies showed that the candidates meet future employers' expectations to a large degree with respect to their competences.

What has been going on over the years inside Aalborg University is also a reflection of what is going on in society and the expectations for a more and better educated population and how universities can support people's aspirations and hopes for the future. The changed perception, that universities are not anymore only for the intellectual elite, has had significant consequences. The so-called 'mass university' came with large student numbers with diverse backgrounds (socially and culturally), putting high demands on increased supervision and guidance from teachers. More physical space is needed and there are cultural challenges to grasp and understand special needs from international students. With increased mobility internationally universities also have to understand the needs of foreign academic staff, and for a university such as Aalborg University it means also the challenge to explain and teach foreigners what it means to apply PBL methodologies to university teaching.

The international society and the Danish state administration place expectations on the universities regarding terms of practices; and related to internationalization and the Bologna process a framework for qualifications, described as employability, mobility and lifelong learning is being implemented [http://ec.europa.eu/education/policy/higher-education/bologna-process\\_en](http://ec.europa.eu/education/policy/higher-education/bologna-process_en). Highlighted are expectations about flexibility and transparency in all aspects of educational programs, which has made it necessary to focus more on leaders' and teachers' abilities in handling the challenges. We see students with many different kinds of backgrounds and desires for their study lives. – Factors of which we have to be very much aware. In fact, the challenge lies in forming learning environments and methods that meet and coordinate expectations from society and the workplaces with students' backgrounds and expectations. In that sense documentations from surveys and experience sharing over the years have shown that the principles and the methodologies, represented in the Aalborg PBL- methodology may be a successful way to handle many of the challenges.

## **Conclusions**

Developing and implementing the PBL-principles and methodologies at Danish universities has not been an easy process. Traditional thinking and existing teaching ideologies within the university culture and society have both been platforms and drivers for changes. It does not mean that teaching has not been changed at the universities during the years – on the contrary there is much development going on within many of the Danish universities.

What made it possible to implement and organise PBL-principles and methodologies at Aalborg University was that the development took place in relation to the establishment of a quite new university, without a history, with new buildings, new staff and researchers, who believed strongly in the

problem-oriented methodologies as ways of initiating and supporting the development of academics for future society and workplaces. At the same time it should be emphasised that the university were established and specifically built on the principles of problem-orientation and group-work and with teachers functioning in new roles – as supervisors.

How the problem-oriented approach is functioning at the university is very much based on values and understandings of the Danish society and its expectations. Therefore this chapter ends by saying that if you wish to implement PBL principles and methodologies in another educational culture, you must be very much aware of the specific educational context in which it is going to be developed, and be conscious about both the possibilities and the challenges, which may lie deeply buried in cultures within the different subject areas. It takes time, and each university has to build up their own way of doing it, however, based on the basic PBL principles.

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